MILITARY MEDICINE

Prehospital Burn Management in a Combat Zone

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Abstract

Objective. The purpose of this article is to provide a descriptive study of the management of burns in the prehospital setting of a combat zone. **Methods.** A retrospective chart review was performed of U.S. casualties with >20% total-body-surface-area thermal burns, transported from the site of injury to Ibn Sina Combat Support Hospital (CSH) between January 1, 2006, and August 30, 2009. **Results.** Ibn Sina CSH received 225 burn casualties between January 2006 and August 2009. Of these, 48 met the inclusion criteria. The mean Injury Severity Score was 31.7 (range 4 to 75). Prehospital vascular access was obtained in 24 casualties (50%), and 20 of the casualties received fluid resuscitation. Out of the 48 casualties enrolled, 28 (58.3%) did not receive prehospital fluid resuscitation. Of the casualties who received fluid resuscitation, nearly all received volumes in excess of the guidelines established by the American Burn Association and those recommended by the Committee for Tactical Combat Casualty Care. With regard to pain management in the prehospital setting, 13 casualties (27.1%) received pain medication. **Conclusions.** With regard to the prehospital fluid resuscitation of primary thermal injury in the combat zone, two extremes were noted. The first group did not receive any fluid resuscitation; the second group was resuscitated with fluid volumes higher than those expected if established guidelines were utilized. Pain management was not uniformly provided to major burn casualties, even in several with vascular access. These observations support improved education of prehospital personnel serving in a combat zone. **Key words:** burn; prehospital; resuscitation; military; combat

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Introduction

Thermal injuries account for approximately 10% of casualties in a combat zone.[1] Resuscitation of these patients can be challenging, even for the provider experienced in burn care. Often, the providers who evaluate and treat burn victims in the first echelons of care in combat have minimal training in resuscitation and the care of burns. Army medics undergo one hour of training in burn resuscitation as part of their educational curriculum. They also have limited supplies in the field, but are typically equipped with intravenous fluids and intramuscular or intravenous analgesia. Previously published literature has described the significant morbidities associated with over- or underresuscitation of burn patients, with consequences ranging from compartment syndromes and pulmonary edema to end-organ hypoperfusion and death.[2] Theater clinical practice guidelines (CPGs) were developed in January 2006 to guide medics and clinicians through the initial management and resuscitation of burn patients.[1,3] More recently, a simplified calculation to determine initial fluid rate, termed the Rule of 10, was also developed at the U.S. Army Institute of Surgical Research (USAISR) and implemented by the Tactical Combat Casualty Care guidelines to guide prehospital personnel and providers involved in the resuscitation and care of burn casualties.[4] To date,

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there has been no descriptive study in the literature of the prehospital care of burn patients in a combat zone.

METHODS

Study Design

The Brooke Army Medical Center Institutional Review Board granted approval of a retrospective medical record review for this study. Patients were identified from a search in the Joint Theater Trauma Registry (JTTR) for burn casualties cared for at Ibn Sina Combat Support Hospital (CSH) in Baghdad, Iraq, between January 1, 2006, and August 30, 2009. The inclusion criteria included U.S. casualties with a >20% total-body-surface-area (TBSA) thermal burn, transported from the point of injury to Ibn Sina CSH. Per the Joint Theater Trauma System CPG for burn care, patients with a ≥20% TBSA burn will receive formal fluid resuscitation.[5] A resuscitation flow sheet is also filled out for these patients to track the volume received by the patient. This is consistent with the recommendations for resuscitation by the American Burn Association (ABA).[2] Exclusion criteria included non-U.S. casualties, <20% TBSA burns, nonthermal burns, and casualties transported from another facility. A standardized abstraction form was used to record the data. Demographic data, including age and gender, were recorded. The mechanism of injury, percentage of TBSA burned, presence of inhalation injury diagnosed by bronchoscopy, and all prehospital interventions, including resuscitation, were recorded. The Injury Severity Score (ISS) for each patient was also accessed through the JTTR. Electronic charts of the patients who met the inclusion criteria were reviewed at the USAISR burn unit. Ventilator days, diagnosis of acute kidney injury, and need for surgical procedures such as laparotomy or fasciotomies were recorded. Data are presented in a descriptive manner. Selected comparisons between groups were analyzed separately using a Student's t-test (for ventilator days) or chi-square test (remaining outcomes compared). Statistical significance was set at $p < 0.05$, and all p-values represent two-tailed calculations.

RESULTS

Ibn Sina CSH received 225 burn casualties between January 2006 and August 2009. Of these, 48 met the inclusion criteria. The mean age was 25 years (range 19 to 41), and all but one were male. The mechanism of injury was explosion in 87.5% of the casualties, followed by exposure to fire (10.4%) and radiator burn (2.1%). The mean ISS was 31.7 (range 4 to 75). Two casualties died at the CSH and one died at Landstuhl Regional Medical Center in Germany. Through bronchoscopy, 19 (39.6%) were diagnosed with an inhalation injury. Of the 48 casualties included in the study, 11 (22.9%) were covered with a blanket, space blanket, or body bag upon arrival to the CSH. Advanced prehospital airway was obtained in four casualties (8.3%). Of these, two underwent endotracheal intubation, one required a cricothyroidotomy, and one was managed with a Combitube. With regard to pain management in the prehospital setting, 13 casualties (27.1%) received pain medication.

Prehospital vascular access was obtained in 24 casualties (50%). Of these, 21 had peripheral intravenous access and three had intraosseous access. Twenty of the casualties received fluid resuscitation. Of these, 16 casualties had thermal injury without major trauma. The time from injury to arrival at the CSH was available for 15 of the 16 burn casualties receiving prehospital fluid resuscitation; the mean time was 43.1 minutes (range 28 to 75 min). All of the casualties who received fluid resuscitation received volumes in excess of those recommended by the Committee for Tactical Combat Casualty Care (CoTCCC) (Table 1).[6]

Of the 15 patients who had thermal burn only and received fluid resuscitation (with known resuscitation amounts and transport times), eight received escharotomies in theater (53.3%). Nine (60%) arrived intubated to the USAISR burn unit and spent an average of 9.2 days on the ventilator. Four of the 15 (26.7%) were diagnosed with acute kidney injury, and two patients (13.3%) underwent laparotomy.

In contrast, of the 48 casualties enrolled, 28 (58.3%) did not receive prehospital fluid resuscitation. The time from injury to arrival at the CSH was available for 57.1% of this subgroup, with a mean time of 26.9 minutes (range 7 to 60 min). Further breakdown of that subset resulted in 19 burn patients without other trauma who received no prehospital fluid resuscitation. Fourteen of these service members (73.7%) had escharotomies performed in theater. Thirteen (68.4%) arrived intubated to the USAISR, with an average of 10.9 days on the ventilator. Nine (47.4%) received a diagnosis of acute kidney injury. Four (21.1%) underwent laparotomy.

In a comparison of the group of patients receiving prehospital fluid resuscitation with those who did not, no statistical significance was found with respect to the incidence of escharotomy, laparotomy, and intubation status on arrival to the USAISR, ventilator days, and acute kidney injury (Table 2).

DISCUSSION

According to the 2008 practice guidelines for burn shock resuscitation published by the ABA, patients with >20% TBSA burn should receive a formal fluid resuscitation, with an estimated need of 2 to 4 mL/kg body weight/% TBSA in the first 24 hours following

TABLE 1. Prehospital Fluid Received in Thermal Burn Injury without Major Trauma

Patient Number	TBSA% Burn	Estimated Time from Injury to Arrival at CSH (min)	Amount Infused (mL)	Infusion Rate (mL/hr)	Patient Weight (kg)	ISR Rule of 10 (mL/hr)	Modified Brooke Formula 1st Hour (mL/hr)	Parkland Formula 1st Hour (mL/hr)
1	20	28	1, 000	2, 143	70	200	175	350
2	20	30	1, 200	2, 400	80	200	200	400
3	20	45	2, 000	2, 667	90	300	225	450
4	20	45	500	667	100	400	250	500
5	25	30	900	1, 800	110	600	344	688
6	26	43	1, 800	1, 116	70	300	228	455
7	26	50	1, 000	1, 200	72	300	234	468
8	27	62	2, 000	1, 936	80	300	270	540
9	34	75	1, 000	800	70	300	298	595
10	40	40	1, 000	1, 500	100	600	500	1, 000
11	55	30	500	1, 000	100	800	687	1, 375
12	57	60	1, 000	1, 000	80	600	570	1, 140
13	60	38	1, 000	1, 579	100	800	750	1, 500
14	72	30	1, 000	2, 000	80	700	720	1, 440
15	80	40	1, 000	1, 500	85	800	850	1, 700

CSH = Combat Support Hospital; ISR = Institute of Surgical Research; TBSA = total body surface area.

injury.[2] Casualties in theater with <20% TBSA burn do not receive a formal fluid resuscitation, and the Joint Theater Trauma System burn resuscitation flow sheet is not initiated. Therefore, there is no comparison data for those with smaller burn size.

As shown in Table 1, with the upper limits of the recommended hourly resuscitation rate by the ABA guidelines (Parkland Formula) in the column on the right, 12 of the 15 subjects received significantly more fluid than predicted in their prehospital course. All of the subjects' resuscitation volumes were greater than those recommended by the CoTCCC.[6] The phenomenon of "fluid creep" has been widely discussed in the burn literature in the past several years; patients often receive increasing amounts of intravenous fluids during resuscitation, sometimes far beyond the predicted amounts.[7–10] Chung et al. also described the concept of "fluid begets fluid," in which resuscitations begun at a higher rate will result in a larger-volume 24-hour resuscitation.[7] The implementation of CPGs in combat theater has improved the resuscitation of burn patients by physician providers. Ennis et al. described the improved outcomes of severely burned patients after these CPGs were disseminated in the deployed setting.[3] The data in this study suggest that it is now time to take this concept to the first responders in the combat zone. For a medic potentially treating multiple casualties at once in a hostile environment, the calculation of the modified Brooke or Parkland formula may be unrealistic prior to beginning fluid resuscitation in the prehospital setting. The USAISR's Rule of 10 is a simplified formula to guide the initial fluid resuscitation of a burn victim. The burn size is estimated to the nearest 10% TBSA. For patients weighing 40 to 80 kg, the burn size is then multiplied by 10 to give the initial fluid rate in milliliters per hour. The rate is increased by 100 mL/hour for every 10 kg above 80 kg in terms of the patient's weight. For the majority of adult burn patients, the Rule of 10 approximates the initial fluid rate within accepted ABA guidelines.[4] This formula, adapted by the CoTCCC in November 2009, provides guidance for medics and other first responders in the combat zone.[6] Although our data were collected prior to the development of the Rule of 10, it will be interesting to analyze prehospital resuscitation a few years after this new guidance has been embedded into medic training programs.

TABLE 2. Prehospital Fluids vs. No Prehospital Fluids in Burn Patients without Major Trauma

Outcome Variable	Received Prehospital Fluids $N = 15$	No Prehospital Fluids $N = 19$	Statistical Significance (p-Value)
Required escharotomy	8	14	0.22
Arrived intubated at ISR	9	13	1.00
Ventilator days	9.2	10.9	0.86
Acute kidney injury	4	9	0.22
Required laparotomy	2	4	0.67

ISR = Institute of Surgical Research.

The patients in the study who received prehospital fluid resuscitation had longer transport times than those who did not receive fluids prior to arrival at the CSH (43.1 min vs. 26.9 min). It is difficult to determine whether the transport time was longer because the time from point of injury to arrival at the CSH was lengthened because of establishment of intravenous access and fluids or whether no resuscitation was started because the transport time was expected to be short. Emphasis should be placed on rapid transport to the higher level of care. Initiation of resuscitation should begin during transport, not hinder the commencement of the transport. Although this study lacks the power to find statistically significant differences in the morbidities of over- or underresuscitation between the prehospital resuscitation groups, there was a trend toward higher incidence of acute kidney injury in the group that received no prehospital fluids compared with those who received prehospital resuscitation (47.4% vs. 26.7%, $p = 0.22$).

This study also highlights other areas of prehospital burn management that may not have as large of an impact on morbidity or mortality but that are important nonetheless: pain control and warming measures. All burn patients should receive some type of device designed to mitigate hypothermia during transport, such as a blanket. Less than a fourth of the patients in our study had documented hypothermia prevention measures in place on arrival to the CSH. This simple measure can improve patient care. Half of the patients (24) who met the inclusion criteria for the study had vascular access obtained in the prehospital setting; however, only 13 (27.1%) received pain medication prior to arrival at the CSH. There were no significant differences in terms of burn size or transport time between those who received analgesia and those who did not. Administration of analgesia may have been limited by the casualty's vital signs or concurrent injuries, but the data remind us that we can strive to better control pain in burn patients at the point of injury.

LIMITATIONS

The primary limitation is the retrospective nature of this study. Other limitations include the descriptive nature of the study as well as the small number of casualties studied. There was also a low capture rate of prehospital data in the JTTR, which required a complete chart review to obtain the data described in this study. The JTTR is meticulously maintained by research nurses in theater; while it is possible that it may contain errors that would result in patients' not being correctly identified by injury, it is the best record we have of combat injuries. Our medical records are as thorough as the providers completing them, which varies from provider to provider.

CONCLUSION

With regard to the prehospital fluid resuscitation of primary thermal injury in the combat zone, two extremes were noted. The first group did not receive any fluid resuscitation; the second group was resuscitated with fluid volumes higher than those expected if established guidelines were utilized. Pain management was not uniformly provided to major burn casualties, even in several with vascular access. Prehospital hypothermia prevention measures were also underutilized. These observations reveal opportunities to improve education and training of prehospital personnel serving in a combat zone, as well as opportunities to improve the overall initial care of burn patients in the deployed setting.

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